

Name \_\_\_\_\_

## Molecular Models

### Your Tasks (Mark these off as you go)

- ☐ Define key vocabulary
- ☐ Draw Lewis structures for molecules
- ☐ Identify the molecular geometry for molecules
- ☐ Identify the bond angles in a molecule
- ☐ Receive credit for this lab

### ☐ Define key vocabulary

**Valence electrons**

**Octet rule**

**Single bond**

**Double bond**

**Triple bond**

**Bonding pair**

**Lone pair**

**Lewis structure**

## Molecular geometry

### □ Draw Lewis structures for molecules

The steps for drawing Lewis structures are as follows,

1. Count the total number of valence electrons present. For polyatomic anions, add the number of negative charges to that total. For polyatomic cations, subtract the number of positive charges from that total.
2. Write the skeletal structure of the compound, using the chemical symbols and placing bonded atoms next to one another. For compounds that contain more than two elements, typically the least electronegative atom occupies the central position.
3. Complete the octets of the atoms bonded to the central atom using the allowed electrons counted in step 1. If there are left over electrons after the octets are complete, place them on the central atom.
4. If the octet of the central atom is not complete after step 3, try adding double or triple bonds between the surrounding atoms and the central atom, using the lone pairs from the surrounding atoms.

#### Example

Draw the Lewis structure for NOF

#### **Step 1: Count the total valence electrons**

N has 5 valence electrons, O has 6, F has 7

The total valence electrons is therefore,  $5 + 6 + 7 = 18$

#### **Step 2: Draw the skeleton structure and deduct the electrons used**

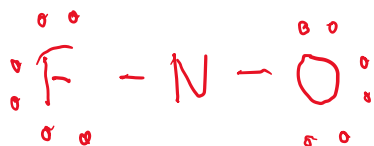


The skeleton structure above required 4 electrons – 2 for each bond. So, we will deduct this from allowed valence electrons from step 1,

$$18 - 4 = 14$$

This number, 14, is the number of electrons we are allowed to complete the structure.

**Step 3: Complete the octets of the atoms bonded to the central atom**



Before we fill the octets, we must remember that we cannot exceed the 14 electrons that we calculated in step 2

The fluorine and the oxygen attached to the nitrogen, already have two from *step 2*. To complete the octets we have to add 6 more electrons to each of these atoms. These electrons are represented as dots around the oxygens above.

Deducting the 12 electrons needed from the 14 that we had leftover in step 2 gives us 2,  $14 - 12 = 2$ .

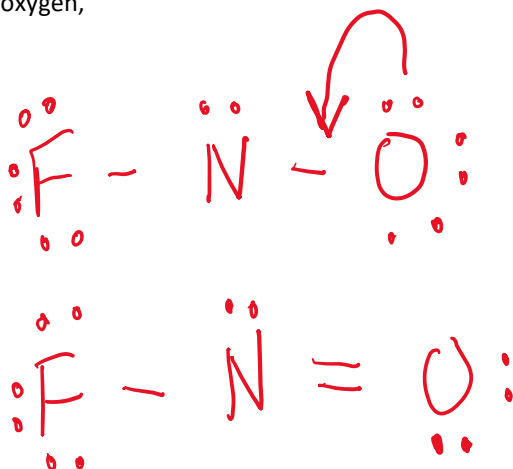
Any left over electrons that we have after completing the octets of the atoms bonded to the central atom go on the central atom,



**Step 4: Inspect the octets of all atoms in the structure. Redistribute electrons to make double or triple bonds as necessary to satisfy the octet of the central atom.**

After completing *step 3*, nitrogen is still short two electrons. To satisfy nitrogen's octet, we need to redistribute electrons to form a double bond between nitrogen and one of the atoms attached to it. But, with which atom should nitrogen double bond with?

Recall that fluorine has 7 valence electrons and therefore will form 1 bond to complete its octet. Oxygen has 6 valence electrons and will therefore form 2 bonds to complete its octet. So, to satisfy nitrogen's octet we will redistribute the electrons on oxygen,



By redistributing oxygen electrons, nitrogen now has an octet and the structure is complete.

Navigate to the Jam Board that corresponds to your lab group. Draw each of the molecules in Data Table 1 on the Jam Board. Then, Complete columns (1) – (4). Draw your completed structure in column 2.

**Data Table 1**

KEY: V.E. = Valence electrons      S. = Structure      L.P. = lone pairs on central atom B.A. = Bonded atoms on central atom      A. = Angles      M.G. = Molecular Geometry						
Molecule	(1) V.E.	(2) S.	(3) L.P.	(4) B.A.	(5) M.G.	(6) A.
CCl <sub>4</sub>						
NF <sub>3</sub>						
CO <sub>2</sub>						
OF <sub>2</sub>						
OFH						
CF <sub>2</sub> Cl <sub>2</sub>						
CNH						
CH <sub>2</sub> O						

## ❑ Identify the molecular geometry for molecules

The molecular geometry of a molecule refers to a molecule's 3D arrangement in space. Different arrangements have different names. The table below is a useful tool for identifying a molecule's molecular geometry.

**Table 1. Geometry of simple molecules**

Bonding atoms	Lone pairs	Geometry	Bond angles	Examples
2	0	Linear	HgCl <sub>2</sub>	180°
3	0	Trigonal planar	BF <sub>3</sub>	120°
4	0	Tetrahedral	CCl <sub>4</sub>	109.5°
5	0	Trigonal bipyramidal	PCl <sub>5</sub>	90° & 120°
6	0	Octahedral	SF <sub>6</sub>	90°
2	1	Bent	SO <sub>2</sub>	<120°
3	1	Trigonal pyramidal	NI <sub>3</sub>	<109.5°
2	2	Bent	H <sub>2</sub> S	<109.5°
4	1	seesaw	XeO <sub>2</sub> F <sub>2</sub>	>90°, <120°
3	2	T-shaped	ClF <sub>3</sub>	90°, 180°
2	3	Linear	I <sub>3</sub> <sup>-</sup>	180°
5	1	Square pyramidal	XeOF <sub>4</sub>	<90°
4	2	Square planar	XeF <sub>4</sub>	90°

Below is an example of how to use the table above to determine a molecule's molecular geometry.



The molecule above has two atoms bonded to the central atom nitrogen and one lone pair on the central atom.

2 bonded atoms and 1 lone pair corresponds to *Bent*.

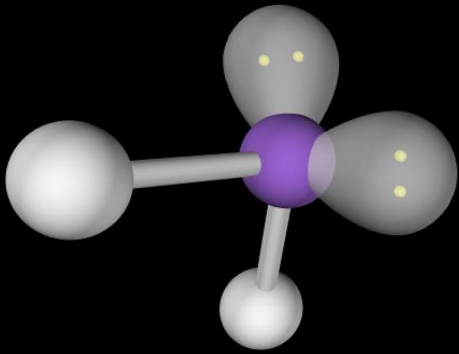
**Return to Data Table 1 and complete column 5.**

### ☐ Identify the bond angles in a molecule

Now let's explore what the above molecules look like in 3D space. Navigate to the following link to open the molecule shape simulator,

[https://phet.colorado.edu/sims/html/molecule-shapes/latest/molecule-shapes\\_en.html](https://phet.colorado.edu/sims/html/molecule-shapes/latest/molecule-shapes_en.html)

<p>Select the "Model" option</p>	
<p>To add or remove bonds click on the types of bonds you want to add or remove from the "Bonding" menu.</p> <p>To remove a single bond, for example, click on the red box with the "x".</p> <p>To add a double bond, click on the double bond icon, etc.</p>	
<p>To add a lone pair, click on the "Lone Pair" icon from the "Lone Pair" menu.</p> <p>To remove a lone pair, click on the red box with the "x".</p>	

<p>You can see the 3D model of the molecule by clicking and dragging it with your mouse.</p>	
<p>To see the molecular geometry, select the "Molecular Geometry" option from the "Name" menu.</p>	<div> <div>Name</div> <div> <input checked="" type="checkbox"/> Molecule Geometry           <input type="checkbox"/> Electron Geometry         </div> <div>Bent</div> </div>
<p>To see the bond angles select "Show Bond Angles" in the "Options" menu.</p>	<div> <div>Options</div> <div> <input checked="" type="checkbox"/> Show Lone Pairs           <input checked="" type="checkbox"/> Show Bond Angles         </div> </div>

**Build all the molecules you drew previously in the simulator. For each molecule, return to Data table 1 and confirm the molecular geometry (column 5). Then, complete column 6.**

**☐ Receive Credit for this lab**

Submit your completed lab to receive credit.